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Chapter

Assessment of Exercise Capacity: A Key Element in Pulmonary Rehabilitation

Paraschiva Postolache, Ștefan Săndulache, Constantin Ghimuș and Alexandru Nechifor

Abstract

Pulmonary rehabilitation (PR) is an extremely effective treatment for people with chronic lung disease, including post-COVID-19, which is still underused worldwide. The capacity for effort and its increase through physical training is a key element that underlies the PR programs being recognized by all specialists in the field in the guides of the American Thoracic Society (ATS)/European Respiratory Society (ERS), American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR), American College of Sports Medicine (ACSM), Global Initiative for Chronic Obstructive Lung Disease (GOLD), etc. The evaluation helps to determine the factors that limit it (ventilators, cardiovascular and muscular factors, etc.), to prescribe the intensity of training, to detect the contraindications of PR, and to evaluate the effectiveness of the rehabilitation program (improving exercise capacity, reducing exercise dyspnea, etc.). In clinical practice, we use two types of investigations on exercise capacity: maximal test (cardiopulmonary exertion test) and submaximal test (6-minute walk test). Based on the systematic review of recent literature and our clinical experience, the chapter will highlight issues related to PR, exercise capacity, and physical training (aerobic, endurance, respiratory muscle) in patients with chronic lung disease.

Keywords: pulmonary rehabilitation, COPD, exercise capacity, dyspnea, quality of life

1. Introduction

We decided to start this chapter by challenging the reader with four questions. Sometimes, the answers can be provocative. However, they stimulate scientific and clinical discussion on this topic:

1. Is pulmonary rehabilitation an effective treatment?

Answer: Pulmonary rehabilitation (PR) is an extremely effective treatment for people with chronic lung disease, including post-COVID-19, still underused worldwide, being recognized by all specialists in the field of the American Thoracic Society
2. Is it important to assess dyspnea for notice the changes in exercise capacity during pulmonary rehabilitation programs?

*Answer:* Yes, dyspnea is a central symptom of a patient with chronic respiratory disease and can be present both at rest and during exertion. Reducing dyspnea is one of the goals of the pulmonary rehabilitation program.

3. What tests are essential in assessing exercise capacity and prescribing a training program?

*Answer:* The 6-minute walk test, cardiopulmonary exercise test, and respiratory muscle strength testing are fundamental.

4. Is physical training (aerobics, endurance, respiratory muscles, etc.) a guarantee to meet the needs of the patient? How should the training intensity be adapted for the patient to cope with the proposed training intensity?

*Answer:* Physical training is an essential component of a PR program. To answer the first question: Yes, the improvement of exercise capacity and muscle strength should be implemented in the daily life of the patient and not only during the PR sessions in specialized centers, to increase their quality of life. We would answer the second question: The intensity of training is determined by the maximum effort capacity obtained in testing, the severity of the condition, the age of the patient, and the severity of comorbidities, using interval and/or continuous training for proper adaptation to training and maximum benefit.

2. Pulmonary rehabilitation: definition, objectives, evaluation

Over the last century, many innovative data and ideas about PR have been accumulated worldwide, as well as the development of an arsenal of techniques for assessing and developing respiratory function. These data and ideas support the progress of modern medicine and the concern about expanding lung disease. With modern industrialization, development of the chemical industry, and urbanization, the human body, and last but not the least, the respiratory system has been exposed to increasingly harmful risk factors.

PR is essential for these patients, being recognized by all specialists. The current definition of PR, according to the Official ATS Workshop Report published on May 2021, is based on the scientifically developed definitions previously developed by PR specialists, which have been published since 1974 and updated in 2006, 2007, 2013, 2015. According to this report, “pulmonary rehabilitation is a comprehensive intervention based on a thorough patient assessment followed by patient-tailored therapies that include, but are not limited to, exercise training, education and behavior change, designed to improve the physical and psychological condition of people with chronic...
respiratory disease and to promote the long-term adherence to health-enhancing behaviors” [1–5].

PR is an extremely effective treatment for people with chronic lung disease, including post-COVID-19, which is still underused worldwide. In recent years, new models of PR programs have emerged, which aim to improve access and adopt these methods to current conditions, such as telerehabilitation and low-cost models, useful for PR at home. Comprehensive and thorough assessment of the patient is essential for personalizing the PR program and for effectively addressing its objectives tailored to each patient. The processes of assessing the quality of life provided by PR are important to ensure that any PR service delivers optimal results for patients and health services. The success of these PR models is evaluated by the way of achieving the essential components of the PR programs (Figure 1) and the results expected by the patient, such as improving exercise capacity, reducing symptoms, especially dyspnea, fatigue, cough, expectoration, chest pain, anxiety and depression, reducing the number and severity of exacerbations involving hospitalization and improving health-related quality of life [1, 4–9].

The initial assessment of patients for inclusion in the PR program needs:

- History and objective examination for the underlying disease and comorbidities;
- Evaluation of the contraindications that may require not starting the PR program;
- Evaluation of the medication and the therapeutic scheme followed until the moment of inclusion in the PR program;
- Smoking status assessment—modified Fagerström test to assess nicotine addiction [10];
- assessment of nutritional status—body mass index (BMI);
- body composition—evaluated by body-plethysmography, which uses the densitometry of the whole body;
- measuring the strength of peripheral muscles;
- symptomatic assessment of:
  - dyspnea (modified Medical Research Council scale—mMRC for the assessment of resting dyspnea and the Borg scale for the evaluation of exertional dyspnea);
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• fatigue Assessment Scale (FAS) [11];
• in patients with asthma, the Asthma Control Test (ACT) questionnaire is also completed;
• in COPD patients, the COPD Assessment Test (CAT) questionnaire is also completed;
• evaluation of the performance of daily activities—the Instrumental Activity of Daily Living (IADL) questionnaire [12, 13];
• quality of life assessment—SF-36 (The 36-Item Short Form Survey) [14];
• evaluation of medical education—Lung Information Needs Questionnaire (LINQ) [15];
• spirometry ± bronchial reversibility test;
• body plethysmography;
• diffusion/transfer through the alveolo-capillary membrane of carbon monoxide (diffusing capacity of lung for carbon monoxide: DLCO / TLCO);
• pulse oscillometry (completes the battery of lung function tests, but is not yet included in the routine assessment);
• electrocardiogram; echocardiography;
• exercise capacity assessment—6-minute walk test (6-minute WT), oximetry test, cardiopulmonary exercise test (CPET);
• chest radiography, chest computed tomography (CT);
• assessment of additional needs (wheelchair, walker, O2, CPAP) [1, 3, 5, 16].

There is no universal program applicable to each patient [17], and the PR team is mentioned in Figure 2:
A pulmonary rehabilitation program, in terms of good adherence to the patient’s treatment, is effective if:

• a reduction in the decline of lung function is obtained;
• an increase in exercise capacity is obtained (for example, improving the 6-minute WT by 10–25% or reducing the sensation of dyspnea during exercise);
• the quality of life is improved by increasing the degree of independence in carrying out daily activities;
• reduces the feeling of dyspnea, fatigue, depression and/or anxiety, etc.;
3. Dyspnea assessment

Dyspnea is the most common symptom responsible for limiting the exercise capacity of patients with chronic respiratory disease and may be present both at rest and during exercise. The ATS defined dyspnea as: “a term used to describe a subjective experience of respiratory discomfort consisting of qualitatively distinct sensations that may vary in intensity; this subjective experience comes from the interaction of multiple physiological, psychological, social, or environmental factors” [19]. It should be noted that the difficulty in defining, describing, and quantifying dyspnea comes from its subjective nature, due to the involvement of psychological, affective, and cognitive factors.

Reducing dyspnea is one of the goals of the PR program. However, dyspnea is a subjective sensation that is not always related to the severity of the disease. The level of dyspnea is assessed at the beginning and in the end of the PR program, but also during cardiopulmonary exercise test, exercise training sessions, etc. [16].

Various valid and reproducible questionnaires are used to measure dyspnea (Figure 3). These must be correlated with other assessment tools, such as respiratory capacity and function.

4. Effort capacity assessment

Effort capacity is the maximum amount of physical effort a patient can withstand. An accurate assessment of exercise capacity requires that the maximum effort be prolonged enough to have a stable (or balanced) effect on circulation and that the patient’s response pattern be consistent when the effort is repeated [26].

The roles of effort assessment are represented by the following:

- determining the factors that limit the capacity of effort (ventilator, cardiovascular, muscular);
- it reduces the number and severity of exacerbations and increases the time until a new exacerbation occurs [18].
• prescribing training intensity;

• detection of contraindications for PR program (e.g., arrhythmia, ischemia, high blood pressure during exercise, etc.);

• evaluation of the effectiveness of the PR program—improving exercise capacity, improving exercise-related dyspnea [27].

In the Respiratory Rehabilitation Clinic of the Rehabilitation Clinical Hospital from Iași, Romania, we routinely use two types of investigations for effort capacity assessment:

• incremental test, maximum: cardiopulmonary exercise test;

• constant submaximal test: 6-minute walk test [16].
4.1 Cardiopulmonary exercise test

At the moment, cardiopulmonary exercise testing (CPET) (Figure 4) is the gold standard for exercise testing, being the method that offers the best accuracy and reproducibility, a clearly superior alternative to conventional exercise tests [25].

In addition to classical exercise tests, which are limited to recording the electrocardiogram, pulse, blood oxygen saturation, blood pressure, and subjectively perceived fatigue (Borg scale), during exercise of progressively increasing intensity, CPET involves real-time assessment, at each inhale-exhale cycle, the spirogram and the concentration of the inhaled gases (oxygen and carbon dioxide). Under these conditions, the test allows on overall assessment of the response to physical exertion, integrating the most important physiological systems of the body: respiratory, cardiovascular, musculoskeletal, and neuropsychic.

CPET is a test of maximum effort when the load increases to max VO\(_2\) or limited symptoms VO\(_2\). This type of test has several phases: rest, heating for 3 minutes, than
incremental phases in ramp or in steps during 1 minute each. The test can be performed with cycle ergometer or on the treadmill (Table 1) [16, 28].

CPET evaluates the following specific and very useful parameters in the PR process:

(a) Maximum oxygen consumption (\( \text{VO}_2 \text{max} \))

- It is the most accurately parameter used to reflect the maximum exercise capacity, respectively, the maximum level of aerobic metabolism, which can be reached during exercise at the peripheral muscle level (Figures 5 and 6).
- Maximum oxygen consumption shows alterations in respiratory pathology, by reducing the level of available peripheral oxygen.
- The periodic evaluation of the maximum oxygen consumption, during PR, allows the objective assessment of the effectiveness of this therapeutic measure, by demonstrating the positive dynamics of \( \text{VO}_2 \text{max} \).
- It has also a prognostic value, so that in COPD patients, values of \( \text{VO}_2 \text{max} \) in the range of 793–995 ml/min associate an average mortality of 5% at 5 years, while values below 654 ml/min associate a mortality of 60% at 5 years [29, 30].

<table>
<thead>
<tr>
<th>Cycle ergometer</th>
<th>Treadmill</th>
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<tbody>
<tr>
<td>• Easy to quantify the power of effort;</td>
<td>• Values of maximum oxygen consumption higher by 7–10% can be reached, due to the training of several muscle groups;</td>
</tr>
<tr>
<td>• The power of the external effort relatively independent of the patient’s weight;</td>
<td></td>
</tr>
<tr>
<td>• Allows ramp protocols, which make it easy to determine the anaerobic threshold;</td>
<td>• Better stimulates a patient’s usual physical activity;</td>
</tr>
<tr>
<td>• Slightly noisy, which makes it easy to measure blood pressure;</td>
<td>• The electrocardiogram shows fewer motion artifacts;</td>
</tr>
<tr>
<td>• Lower risk of injury;</td>
<td>• is easier to use for testing low height patients.</td>
</tr>
<tr>
<td>• Requires less space.</td>
<td></td>
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</table>

Table 1.
Comparative advantages of the exercise test on the cycle ergometer, respective treadmill [28].

Figure 5.
Limitation of functional capacity according to the value of maximum oxygen consumption [29].
(b) Ventilatory or anaerobic threshold (AT) (Figure 6)

- Represents the level of the oxygen consumption at which the cellular metabolism in the peripheral muscles changes from aerobiosis to anaerobiosis, with the increase of lactic acid production, CO$_2$, and reflex hyperventilation.

- AT is expressed as the value of oxygen consumption at that time or as a percentage of the predicted value of VO$_2$ max.

- In healthy individuals, AT is in the range of 45–65% of VO$_2$ max.

- In patients with chronic lung disease, AT is usually reduced to below 40% of VO$_2$ max (indicating a limitation of tissue oxygen supply).

- Anaerobic threshold is an essential parameter for establishing the optimal level of exercise intensity in PR programs.

- Both at the beginning of the PR program and during it, it is recommended to keep a level of intensity below the anaerobic threshold, the recommended physical exercise being aerobic [29].

(c) Minute ventilation (VE)

- CPET measures ventilation per minute, breath by breath, but also the dynamics of current volume and respiratory rate during exertion, which defines the ventilatory strategy [29].

(d) Inspiratory capacity

- It can be evaluated periodically during CPET, by forced inspiration maneuvers and allows the quantification of dynamic hyperinflation [29].
4.2 The 6-minute walk test

The 6-minute walk test (6MWT) (Figure 7, Tables 2 and 3) is a constant and submaximal load exercise test (unlike CPET, which is performed at an increasing, incremental load). It is also part of the BODE prognostic index. As a way of doing things, 6MWT involves:

- The patient, who travels a distance on flat ground for 6 minutes; the number of laps is multiplied by the distance.

- The walking corridor must have an acceptable distance of 30–50 meters.

- The following are evaluated during the test: heart rate, blood pressure, blood saturation, degree of dyspnea (both initially and at the end of the test), and the distance expressed in meters.
### Indications, Contraindications and Limitation of 6MWT [16, 31, 32]

- **Indications**
  - Assessment of functional status and disability in COPD, pulmonary fibrosis, cystic fibrosis, pulmonary vascular disease, heart failure;
  - Recent myocardial infarction (1 month);
  - Developmental thrombophlebitis and/or recent pulmonary embolism;
  - Prediction of COPD mortality and morbidity, pulmonary hypertension, pulmonary fibrosis, heart failure;
  - Tachycardia >80% of the theoretical maximum heart rate (calculated according to the formula: 220—age in years);
  - Acute pericarditis;
  - Hypertensive emergency;
  - Bronchospasm crisis;
  - Hypertensive emergency;
  - Fever;
  - Resting tachycardia (>120/minute) (relative contraindication);
  - Prediction of COPD mortality and morbidity, pulmonary hypertension, pulmonary fibrosis, heart failure;
  - At the express request of the patient.
  - Prediction of COPD mortality and morbidity, pulmonary hypertension, pulmonary fibrosis, heart failure;
  - Blood pressure >180/100 at rest (relative contraindication).

- **Contraindications**
  - Chest pain;
  - Intolerable dyspnea;
  - Unstable angina;
  - Vertigo;
  - Episond of respiratory decompensation with acidosis;
  - Extreme weakness;
  - Tachycardia >80% of the theoretical maximum heart rate (calculated according to the formula: 220—age in years);
  - Recent myocardial infarction (1 month);
  - Developmental thrombophlebitis and/or recent pulmonary embolism;
  - Unstable angina;
  - Tachycardia >80% of the theoretical maximum heart rate (calculated according to the formula: 220—age in years);  
  - Desaturation <85%;
  - Hypertensive emergency;
  - Fever;

- **Test interruption**
  - Intolerable dyspnea;
  - Unstable angina;
  - Vertigo;
  - Episode of respiratory decompensation with acidosis;
  - Extreme weakness;
  - Tachycardia >80% of the theoretical maximum heart rate (calculated according to the formula: 220—age in years);
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  - Unstable angina;
  - Vertigo;
  - Episode of respiratory decompensation with acidosis;
  - Extreme weakness;
  - Tachycardia >80% of the theoretical maximum heart rate (calculated according to the formula: 220—age in years);
  - Desaturation <85%;

- **Titration of oxygen flow at exertion.**

- The patient must walk as far as possible in 6 minutes, walking at his own rhythm, sustained, between the two ends of the aisle, marked with two cones, without running. The patient can stop to rest during the 6 minutes, but must resume walking as soon as possible, the test not lasting with rest time.

- 6MWT results can be expressed as absolute value, percentage of initial value, or percentage of predicted value [16, 31].

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Because there are different practices regarding the actual conduct of the test, leading to variable and hard-to-compare results, the international ATS guideline has established clear rules for 6MWT standardization [31, 33].

The following predictable equation, recommended for COPD patients, was used to interpret the results:

- For men: test value (m) = \( 867 - \left( \frac{5.71}{\text{age}} \right) + \left( \frac{1.03}{\text{height}} \right) \)
- For women: test value (m) = \( 525 - \left( \frac{2.86}{\text{age}} \right) + \left( \frac{2.71}{\text{height}} \right) - \left( \frac{6.22}{\text{BMI, kg/m}^2} \right) \) [31, 32].

The 6-minute walk test is considered positive for an improvement of at least 54 meters compared with the initial assessment [7, 16].

Dosed physical training is one of the most important components of physical therapy and PR programs. The exercise plan is individualized for each patient according to the underlying disease and the degree of severity, age, sex, associated diseases, training methods, duration, pace, intensity of effort, motivation, and choice of the patient [35–38].

Exercise will address different muscle groups:

- to increase the endurance of the muscles of the lower limbs, it is recommended to walk on the treadmill, pedal to the cycle ergometer (Figure 8) or to counteract some weights. Exercises should also be performed by people immobilized in a sitting or supine position for limb movement, increased flexibility and decreased joint stiffness, the exercises being focused on stretching, coordination, and attention;

Table 3. Advantages and disadvantages 6MWT [31, 33, 34].

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantage</th>
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<tr>
<td>Simple;</td>
<td>Depends on the motivation of the patient and/or the supervisor;</td>
</tr>
<tr>
<td>Cheap;</td>
<td>Good reproducibility (if the standard protocol is followed);</td>
</tr>
<tr>
<td>Correlates with the prognosis;</td>
<td>Measures a single variable (distance traveled);</td>
</tr>
<tr>
<td>Can be applied to all patients (regardless of age, level of readiness, degree of respiratory failure);</td>
<td>More difficult to standardize and less reproducible than the maximum effort tests;</td>
</tr>
<tr>
<td>Is a very useful tool in PR programs—it must be done before and after the end of the program, in order to highlight the increase of the distance traveled, with a direct impact in increasing the quality of life.</td>
<td>Does not allow the detection of the causes of the effort limitation.</td>
</tr>
</tbody>
</table>

Because there are different practices regarding the actual conduct of the test, leading to variable and hard-to-compare results, the international ATS guideline has established clear rules for 6MWT standardization [31, 33].

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Exercise will address different muscle groups:

- to increase the endurance of the muscles of the lower limbs, it is recommended to walk on the treadmill, pedal to the cycle ergometer (Figure 8) or to counteract some weights. Exercises should also be performed by people immobilized in a sitting or supine position for limb movement, increased flexibility and decreased joint stiffness, the exercises being focused on stretching, coordination, and attention;
to increase the endurance of the muscles of the upper limbs, the patients will perform exercises with weights or stretching;

- for the chest muscles, stretching, swimming, training on the cycle ergometer or on the treadmill are recommended;

- gymnastics for the neck and head muscles;

- breathing techniques (abdominal breathing, etc.) (Figure 9) [26, 35, 36].

4.3 Respiratory muscle assessment

Respiratory muscle training is a valuable method that provides additional PR benefits, improving both muscle strength and endurance, with clinical benefits in
COPD patient (and not only) who remain symptomatic despite optimal therapy [39]. The purpose of respiratory muscle training is to improve respiratory muscle function, hypoxia, hypoventilation, and relieve dyspnea [40].

Before starting the training program, the maximum inspiratory pressure at the level of the oral cavity will be evaluated, which represents the exercise capacity of the inspiratory muscles, the methods and equipment used for the two types of training being significantly different (Figure 10) [41].

Respiratory muscle training involves training the inspiratory and expiratory muscles (Figure 11). Depending on the type of exercise, training can be strength (consisting of a series of repeated breaths with increased endurance) or endurance (forced ventilation maintained for several minutes). In general, inspiratory muscle training is used in patients with dyspnea, as a predominant symptom, and expiratory muscle training in patients with productive cough [42].

Respiratory muscle training should be continued after the discharge of patients from PR centers, daily, independently or in association with the PR program, at home, and, if possible, in specialized PR centers, at least two to three times a week, in order to maintain the effects of training [5].

5. Factors that limit the capacity of effort

The function of the respiratory and cardiovascular systems is adequately tested only during physical exertion. Each of the two systems has a reserve capacity well
above that required to support the normal functioning of the body at rest and during moderate physical activity. Many pathologies that affect breathing or circulation cause progressive loss of physiological function. Such diseases are likely to be manifested initially by a reduction in lung or cardiac reserve. Because reserve abilities are tested only during exertion, the early (and potentially curable) stages of such diseases can only cause symptoms with exertion. By assessing the maximum capacity of patients to exercise, the pulmonologist or cardiologist assesses, at least in qualitative terms, the reserve capacity of each of the organ systems that contribute to the response to exertion [25].

Exercise performance reflects a coordinated response of respiratory and cardiovascular function along with the action of the muscles being trained. Physical exertion induces gradual increases in the frequency and depth of respiration, heart rate, blood pressure, heart rate, and myocardial contractility. During constant exertion, the respiratory and cardiovascular parameters begin to stabilize (after 1–2 minutes of rapid change) at appropriate levels, for a certain intensity of exercise in a certain patient. These balance levels can be used to characterize patient performance.

Effort capacity is the maximum amount of physical exertion a patient can endure, and exercise intolerance is a condition in which the patient is unable to exercise at the level and/or duration that would be expected from someone of his age and general physical condition (Figure 12).

Exercise intolerance in patients with chronic lung disease is multifactorial in nature, involving the following:

- ventilatory abnormalities:

  - during exercise of progressively increasing intensity, healthy elderly people can increase their breathing rate and current volume to provide an increase of up to 10–15 times the ventilation per minute, which is essential to eliminate the production of carbon dioxide and satisfies the increased oxygen demand → in such cases, ventilatory function is often not the limiting factor, at least for a wide range of submaximal stress levels, as ventilation per minute is maintained well below maximum ventilatory capacity (Figure 13);
• reduced ventilatory capacity during exercise is due to abnormal respiratory mechanics and respiratory muscle dysfunction;

• in patients with chronic respiratory disease, high resistance of the inspiratory and expiratory airways and/or reduced compliance may substantially increase the pressure required for airflow and thus my increase respiratory labor — the respiratory muscles are frequently weakened and unable to withstand adequately due to the presence of hyperinflation and/or intrinsic muscle dysfunction/hypoperfusion;

• a ventilatory demand is increased during physical exertion due to gas exchange abnormalities (e.g., change in ventilation/perfusion ratio and increased dead spate ventilation), which leads to hypoxemia and [28, 44–46].

• gas exchange anomalies:

  • despite the deterioration of the ventilatory reserve with aging, healthy elderly people seem to be able to maintain alveolar ventilation at a level that allows blood gases to be kept within normal limits, even during intense exercise — the ventilation/infusion ratio remains good because both ventilation, and the infusion increase several times with increasing exercise intensity — alveolo-capillary diffusion remains intact and, consequently, PaO2 remains normal, even at high exercise intensities;

  • gas exchange regulation is affected in chronic lung disease producing various abnormalities of ventilation/perfusion ratio, diffusion disorders, and hypoxemia at rest and during exertion — many patients with severe lung disease experience arterial oxygen desaturation during exertion [28, 47–49].

• cardiovascular disorders:

  • cardiac output in healthy subjects may increase several times in response to physical exertion;
• in chronic lung diseases, mechanisms involving oxygen transport are frequently affected, leading to a reduction in cardiovascular function:

• first, coexisting right and left ventricular dysfunction can affect exercise capacity due to decreased cardiac output, which often leads to impaired oxygen delivery and early development of metabolic acidosis;

• secondly, in chronic lung diseases, especially in the presence of pulmonary vascular abnormalities, pulmonary hypertension and right ventricular dysfunction may develop;

• these phenomena may worsen in the presence of hyponemia → increased pulmonary vascular resistance and pulmonary arterial hypertension, with consecutive right heart failure;

• increased cardiac output, along with low oxygen content, reduces systemic oxygen delivery to all organs of the body, including skeletal muscle [28, 50–53].

• peripheral muscle dysfunction:

• inactivity, muscle deconditioning, and fatigue are associated with lower muscle mass and impaired muscle fiber distribution, especially with regard to the proportion of type I fibers (slow shrinking oxidative);

• reducing the proportion of oxidative fibers reduces the oxidative potential of muscles, which are more prone to fatigue during high-intensity exercise;

• structural and metabolic abnormalities of the limb muscles can lead to early lactic acidosis and failure of pregnancy due to exertion [54–57].

6. Conclusions

Patients with chronic lung disease have varying degrees of activity limitation due to skeletal and respiratory muscle dysfunction, a limitation that is remedied by physical training in the complex PR program.

Pulmonary rehabilitation is on the basic therapies, with strong scientific evidence and an essential role in the management of chronic respiratory diseases. PR is a valuable treatment tool, a source of measurement and information tools for respiratory pathophysiology.

As an essential part of chronic lung disease management, PR relieves dyspnea and fatigue, anxiety, and depression, improves exercise tolerance and health-related quality of life, and reduces the number of hospitalizations for exacerbations and mortality of patients with chronic lung disease. Exercise training is the key component of PR, which consists of exercise evaluation and actual training therapy. Exercise assessments are an important component of PR and should take into account patients’ symptoms, endurance, strength, and health-related quality of life.
Dyspnea is an important symptom of chronic, multifaceted lung disease, and its understanding can be derived from a multidisciplinary and multidimensional approach.

The ability to walk is a quick and inexpressive measure of functional status and an important component of quality of life, reflecting a person’s autonomy, which is significantly reduced in patients with chronic lung disease.

Functional measures at rest do not always provide an accurate diagnosis and adequate stratification of severity in patients with chronic respiratory disease. That is why cardiopulmonary exercise testing is necessary, which provides useful information about exercise capacity and a comprehensive assessment of pathological mechanisms that limit exercise tolerance.

Both respiratory and cardiovascular fitness and exercise capacity are key elements in pulmonary rehabilitation programs. These parameters allow for the optimal prescribing of exercise programs and the inclusion of patient in physical training groups, which will lead to an increase in the effectiveness and safety of lung rehabilitation therapy for chronic respiratory patients.

Conflict of interest

The authors declare no conflict of interest.

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